ACCESSION NR: AP4041706

statistical equilibrium, and the system is spatially homogeneous. It is shown that an important factor in the feasibility of laser action is the spacing of the singular modes, and monochromatic emission is possible in principle if the spacing is large. Future plans call for investigations of induced emission for systems with impurities and the use of x-rays or gamma rays for pumping. Orig. art. has: 56 formulas.

ASSOCIATION: Institut fiziki AN UkrSSR Kiev (Institute of Physics, AN UkrSSR)

SUBMITTED: 24Feb64 ATD PRESS: 3076 ENCL: 00

SUB CODE: EC, GP NR REF SOV: 004 OTHER: 004

ACCESSION NR: AP4042121 P/0034/64/000/006/0245/0248

AUTHOR: Negrusz, Adam (Docent, Doctor, Engineer)

TITLE: Measuring the pulsating flow rate by means of standard gauges

SOURCE: Pomiary, automatyka, kontrola, no. 6, 1964, 245-248

TOPIC TAGS: pulsating flow, flowmeter

ABSTRACT: This article points out the errors occurring in measurements of flow rates and their effect on the accuracy of measurements. The errors accruing from the elements of the measuring system (the reducing pipe, pulse conductors, and differential manometer), the nonlinear relationship between the flow rate and the pressure drop, pulse sources, and flow system are discussed in detail and suggestions made for diminishing them. It is noted that some of the errors are unavoidable at the present time since the problem of pulsating flow in the pipes of pumps, compressors, internal combustion engines, etc. has not been satisfactorily solved. Orig. art. has: 20 formulas and 4 figures.

Card 1/2

ACCESSION NR: AP4042121

ASSOCIATION: Katedra Miernictwa Energetycznego Politechniki Wroclawskiej (Power Measurement Department, Wroclaw Engineering College)

SUBMITTED: 00 ENCL: 00 SUB CODE: IE

NO REF SOV: 003 OTHER: 007

Card 2/2

ACCESSION NR: AP4034918 S/0181/64/006/005/1388/1398

AUTHORS: Dy*kman, I. M.; Tomchuk, P. M.

TITLE: The effect of majority carriers in semiconductors on the mobility of minority carriers

SOURCE: Fizika tverdogo tela, v. 6, no. 5, 1964, 1388-1398

TOPIC TAGS: semiconductor, majority carrier, minority carrier, drift velocity, Coulomb mobility

ABSTRACT: The authors examined semiconductors with various carriers at very different concentrations, and they solved the kinetic equations for minority carriers. Under certain conditions it is found that the distribution of minority carriers is approximately Maxwellian, with the temperature of majority carriers. The mobility of the minority carriers has also been computed. When there is no substantial lattice scattering, the minority mobility is determined by the Coulomb mobility multiplied by a function that holds for all semiconductors and that depends only on the ratio of effective carrier masses. The effect of entrapment is determined by this function. When the charges on the carriers are of opposite sign, the mobility of the minority carriers becomes negative when the mass of these carriers

ACCESSION NR: AP4034918

is greater than the mass of the majority carriers. When the masses of minority carriers differ significantly from each other, the situation is the same as when some charges are positive, some negative. The drift velocity will be determined by the average mobility. Orig. art. has: 3 figures and 43 formulas.

ASSOCIATION: Institut poluprovodnikov, AN USSR (Institute of Semiconductors, AN UkrSSR); Institut fiziki, AN UkrSSR, Kiev (Institute of Physics, AN UkrSSR)

SUBMITTED: 18Nov63 ENCL: 00

SUB CODE: EC NO REF SOV: 007 OTHER: 005

Card 2/2

BORZYAK, P.G.; SARBEY, O.G.; TOMCHUK, P.M.

Symposium on Hot Electrons, held in Kiev. Vest. AN SSSR 33 no.10: 100-102 O '63. (MIRA 16:11)

DYKMAN, I.M.; TOMCHUK, P.M.

Anisotropy of the conductivity of hot electrons and electron interaction. Fiz. tver. tela 7 no.1:286-289 Ja '65. (MIRA 18:3)

1. Institut poluprovodnikov AN UkrSSR i Institut fiziki AN UkrSSR, Kiyev.

Card 1/2

APPROVED FOR RELEASE: 04/03/2001 CIA-RDP86-00513R001756210018-0"

11175

S/181/62/004/012/028/052
B125/B102

AUTHORS: Dykman, I. M., and Tomchuk. P. M.

TITLE: The electrical conductivity of polar semiconductors with allowance for electron-electron interaction

PERIODICAL: Fizika tverdogo tela, v. 4, no. 12, 1962, 3551-3563

TEXT: The temperature and concentration dependences of the electron mobility $\mu = \sigma/e_0 n$ in polar semiconductors are calculated allowing for the scattering of electrons from longitudinal and optical vibrations, from impurity ions and from other electrons. σ is the conductivity, e_0 is the charge and n is the electron concentration. A homogeneous polar crystal, whose conduction electron concentration is constant as to space and time and which incorporates impurity centers (near the bottom of the conduction band) having the concentration N, is assumed to be placed in a homogeneous electric field F. The dispersion law is assumed to be parabolic. In the dispersion equation (1):

$$(\partial f/\partial t)_F + (\partial f/\partial t)_L + (\partial f/\partial t)_P + (\partial f/\partial t)_e = 0$$

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The electrical conductivity ... S/181/62/004/012/028/052
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the first term denotes the change in the distribution function

$$f_-(\vec{p}) = f_0(p) + \cos\vartheta f_1(p)(\cos\vartheta = p_F/p)$$

of the conduction electrons under the influence of an electric field. The remaining terms denote the effect of electron interaction with the lattice, with the impurity ions and with themselves. After introducing dimensionless variables and functions

$$x^2 = \frac{p^2}{2mkT}, \qquad (10),$$

$$\xi_0(x) = \frac{1}{n}(2\pi mkT)^{3/2} f_0(x), \quad \xi_1(x) = \frac{1}{n}(2\pi mkT)^{3/2} f_1(x), \qquad (11),$$

the operator equation

$$\alpha L_1\left[\eta(x)\right] + L_2\left[\eta(x)\right] = \gamma_2 U(x)$$

is derived from (1) following a method developed by the authors (e.g. FTT, (1) 3, 1909, 1961; FTT (2) 4, 1082, 1962) using

Card 2/8 (1) S/181/61/003/007/001/023
(2) S/181/62/004/005/002/055

$$\left(\frac{\partial f}{\partial t}\right)_L = \left(\frac{\partial f_0}{\partial t}\right)_L + \cos\vartheta \left(\frac{\partial f_1}{\partial t}\right)_L, \tag{3}$$

$$\left(\frac{\partial f_0}{\partial t}\right)_L = -\frac{e_0 F_0 N_0}{p}\Big\{\left[f_0(\varepsilon) - e^{x_0} f_0(\varepsilon + k\theta_0)\right]\Phi(\varepsilon) + \left[e^{x_0} f_0(\varepsilon) - f_0(\varepsilon - k\theta_0)\right]\Phi(\varepsilon - k\theta_0)\, u(\varepsilon - k\theta_0)\Big\}, \tag{4}$$

$$\left(\frac{\partial f_1}{\partial t}\right)_L = -\frac{e_0 F_0 N_0}{p}\Big\{f_1(\varepsilon)\Phi(\varepsilon) - e^{x_0} f_1(\varepsilon + k\theta_0)\left[\frac{2\varepsilon + k\theta_0}{2\sqrt{\varepsilon(\varepsilon + k\theta_0)}}\Phi(\varepsilon) - 1\right] + f_1(\varepsilon)\Phi(\varepsilon - k\theta_0) e^{x_0} u(\varepsilon - k\theta_0) - f_1(\varepsilon - k\theta_0) \times \left[\frac{2\varepsilon - k\theta_0}{2\sqrt{\varepsilon(\varepsilon - k\theta_0)}}\Phi(\varepsilon - k\theta_0) - 1\right] u(\varepsilon - k\theta_0)\Big\}. \tag{5}$$

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B125/B102

as obtained by R. Stratton (Proc. Roy. Soc., 246A, 406, 1958), which holds where the electrons interact with optical vibrations only. The self-adjoint and positive definite operator L_1 denotes the electron-electron scattering and the operator L_2 the scattering from optical vibrations and from impurity ions. It is perhaps possible to solve (21) by iteration, but the calculation would be lengthy. For small field strengths and at $T = T_0$ (T_0 is the lattice temperature) it is, however, possible to solve (21) by a method of variations worked out by P. M. Tomchuk (FTT, 3, 1258, 1961). The equations

$$\sigma = \frac{\sqrt{\pi}}{3}\frac{m\varkappa^2}{e_0^2\ln(h/b_0)}\left(\frac{2kT_0}{\pi m}\right)^{3/2}\left\{\frac{9\pi}{64\int\limits_0^\infty Q\left[xe^{-x^2}\right]dx}+\frac{b_1^2}{L_{11}}+\sum_{n=2}^{\infty}\frac{(D_1^{(n-1)})^2}{D^{(n-1)}D^{(n)}}\right\} \quad (27),$$

$$D^{(n)}=\begin{vmatrix} L_{11}, & L_{12}, & \dots & L_{1n} \\ L_{21}, & L_{22}, & \dots & L_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ L_{n1}, & L_{n2}, & \dots & L_{nn} \end{vmatrix}, \quad D_b^{(n-1)}=\begin{vmatrix} L_{11}, & L_{12}, & \dots & L_{1,n-1}, & b_1 \\ L_{21}, & L_{22}, & \dots & L_{2,n-1}, & b_2 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ L_{n1}, & L_{n2}, & \dots & L_{n,n-1}, & b_n \end{vmatrix}, \quad (28),$$

$$L_{mn}=L_{nm}=aL_{mn}^{(1)}+L_{mn}^{(2)}, \quad (29),$$

the matrix elements

$$L_{mn}^{(2)}=\int_0^\infty x^{2m-1}L_2\left[x^{2n-1}\right]dx \quad \text{and}$$

$$L_{mn}^{(1)}=\frac{1}{4mn}\left[(m,n)-\frac{(m,0)(0,n)}{(0,0)}\right]. \quad (36)$$

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The electrical conductivity ...

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lead to

$$\mu = \frac{3\sqrt{\pi}}{8}\frac{1}{N_0F_0}\left(\frac{2kT_0}{m}\right)^{1/2}\frac{\gamma}{(0,0)}\left[1+\frac{b_1^2}{L_{11}}+\frac{(L_{11}b_2-L_{12}b_1)^2}{L_{11}(L_{11}L_{22}-L_{12}^2)}+\cdots\right]. \quad (40),$$

which describes the mobility, and for sufficiently low temperatures to

$$\frac{\mu}{(\mu_0)_{T_0>\theta_0}} = \frac{9\pi}{32}\frac{\gamma}{(0,0)}\left[1+\frac{b_1^2}{L_{11}}+\frac{(L_{11}b_2-L_{12}b_1)^2}{L_{11}(L_{11}L_{22}-L_{12}^2)}+\cdots\right], \quad (43),$$

$$\frac{\mu}{(\mu_0)_{T_0<\theta_0}} = \frac{3}{4}\left(\frac{\pi}{z_0}\right)^{1/2}\frac{\gamma}{(0,0)}\left[1+\frac{b_1^2}{L_{11}}+\frac{(L_{11}b_2-L_{12}b_1)^2}{L_{11}(L_{11}L_{22}-L_{12}^2)}+\cdots\right]. \quad (44).$$

The effect of the Coulomb scattering mechanism increases with decreasing T_0. Fig. 1 shows the temperature dependences of the relative mobility. With
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increasing concentration, the relative mobility $\mu/(\mu_0)_{T_0 \gg \theta_0}$ increases at first more strongly and then more weakly. The smaller $z_0 = \theta_0/T_0$, the larger is the value of the relative mobility.

ASSOCIATION: Institut poluprovodnikov AN USSR (Institute of Semiconductors AS UkrSSR); Institut fiziki AN USSR, Kiyev (Physics Institute AS UkrSSR, Kiyev)

SUBMITTED: July 9, 1962

Fig. 1. The dependence of the relative mobility on z_0. Solid curve for a constant value of the parameter γ: (1) $\gamma = 10$, (2) $\gamma = 5$, (3) $\gamma = 2$, (4) $\gamma = 1$, (5) $\gamma = 0.5$. Dot-dashed curve $\gamma \to \infty$. Dashed curves at constant concentration: (6) $n = n_1$, (7) $n \simeq n_1/40$, (8) $n \simeq n_1/80$, (9) $n \simeq n_1/250$

$$\mu_I = \frac{2m\varkappa^2}{ne_0^3 \ln(h/b_0)} \left(\frac{2kT_0}{\pi m}\right)^{3/2}; \qquad \gamma = \frac{\mu_I}{3(\mu_0)_{T_0 \gg \theta_0}}$$

L 21238-66 EWT(1)/EWT(m)/T/EWP(t) IJP(c) JD/GG/AT
ACC NR: AP6003814 SOURCE CODE: UR/0181/66/008/001/0276/0278

AUTHORS: Tomchuk, P. M.; Fedorovich, R. D.

ORG: Institute of Physics AN UkrSSR, Kiev (Institut fiziki AN UkrSSR)

TITLE: Emission of electrons from thin metallic film

SOURCE: Fizika tverdogo tela, v. 8, no. 1, 1966, 276-278

TOPIC TAGS: electroluminescence, electron emission, gold, electron temperature, volt ampere characteristic

ABSTRACT: This is a continuation of earlier work by one of the authors (Fedorovich, with P. G. Borzyak and O. G. Sarbey, Phys. stat. sol. v. 8, 55, 1965), dealing with electroluminescence and electron emission from thin gold films, enhanced by reducing their work functions and attributed to the appearance of sufficiently hot electrons in the films. In the present note the authors consider the mechanism that leads to the heating of the electrons in such films. As in the earlier paper, it is assumed that the film constitutes a system of metallic islands, randomly distributed over the surface of a dielec-

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tric. The electron temperature is constant in each island. Formulas are given for the power received by the electrons from the field and for the power given up to the atoms in the film. It is deduced from the power balance and from the equations for the emission current that the logarithm of the emission current should be proportional to the reciprocal of the square root of the product of the conduction current and the voltage applied to the film. This dependence is found to agree with the experimental data so that it is assumed that the proposed mechanism is indeed the one realized in the film. The authors thank P. G. Borzyak and O. G. Sarbey for participating in the discussions. Orig. art. has: 1 figure and 5 formulas.

SUB CODE: 20/ SUBM DATE: 03Aug65/ ORIG REF: 001/ OTH REF: 002

Card 2/2 dda

DYKMAN, I.M.; TOMCHUK, P.M.

Effect of an electric field on the electron temperature, conductance, and thermoelectronic emission in semiconductors. Part 5. Fiz. tver. tela 4 no.5:1082-1094 My '62. (MIRA 15:5)

1. Institut poluprovodnikov AN USSR i Institut fiziki AN USSR, Kiyev.

(Semiconductors--Electric properties)
(Electric fields)

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S/181/62/004/005/002/055
B102/B104

AUTHORS: Dykman, I. M., and Tomchuk, P. M.

TITLE: The effect of an electric field on the electron temperature, the electrical conductivity, and the thermionic emission from semiconductors. V

PERIODICAL: Fizika tverdogo tela, v. 4, no. 5, 1962, 1082 - 1094

TEXT: The results obtained in earlier papers (FTT, 2, 2228, 1960; 3, 1909, 1961) are here generalized to the case where the concentration of conduction electrons differs from that of the impurity ions. First of all, the factor β is determined, which characterizes the deviation of the conductivity of a semiconductor under the action of an electric field F from the ohmic value; $\sigma = \sigma_0 (1 + \beta F^2)$, where σ_0 denotes ohmic conductivity for $F \to 0$. β has been determined many times previously, but a certain generalization is made here. The effect of interaction among electrons is taken into account, but that of optical lattice vibrations is ignored. The effective carrier mass is assumed to be independent of

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temperature. The equation

$$\beta = -\frac{e_0^2 l^2}{2ms^2 kT_0}\left\{\gamma_3\gamma_\varepsilon - 4\gamma_3\left[1 - \frac{3}{4\ln\left(\frac{h}{b_0}\right)}\right]\frac{d(\gamma_3\gamma_\varepsilon)}{d\gamma_3}\right\}_0 .$$

with

$$\gamma_3 = \frac{(kT)^2}{2\pi n l e^4 \ln\left(\frac{h}{b_0}\right)} .$$

is obtained, which leads to the well-known formula $\beta = \beta_a = -(3\pi/64)(\mu_a/s)^2$ for the case of pure lattice scattering (Gunn, Progress in Semiconductors, 2, 211, New York, 1957). An explicit formula for β is also given for the case of pure impurity scattering. The ratio β/β_a as a function of γ_3 is investigated, for which purpose

$$\gamma_3 = \frac{4e^2}{9lkT_0\ln\left(\frac{h}{b_0}\right)}\left(\frac{h}{b_0}\right)^2 ,$$

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is particularly suitable. If $\gamma_3 = 1$ (conductivity amounts to 75% of the maximum), $\beta = 0.33\beta_a$; for $\gamma_3 = 4$, $\beta \leq 0.6\beta_a$. The role of electron-electron interaction is investigated for various concentrations of electrons and impurity ions. This, for example, is the case with an n-type semiconductor which contains both donor and acceptor ions. Various relations are derived, including one between the electron temperature $\bar{T}$ and the current $\bar{j}$:

$$\frac{T}{T_0}\left(\frac{T}{T_0}-1\right)=\frac{(e_0Fl)^2}{ms^2kT_0}\gamma_3\gamma_E(\gamma_3,\gamma_4);\quad j=\frac{16e_0^2nlF}{(2\pi mkT)^{1/2}}\gamma_3\gamma_E(\gamma_3,\gamma_4),$$

In the following, the effect of interaction between electrons and optical lattice vibrations is investigated. The equations

$$\frac{T}{T_0}-1+b\frac{k\theta_0}{8ms^2}\frac{\operatorname{sh}\left(\frac{\alpha_0-\alpha}{2}\right)}{\operatorname{sh}\left(\frac{\alpha_0}{2}\right)}\alpha\alpha_0K_1\left(\frac{\alpha}{2}\right)=\frac{1}{12}\frac{(e_0Fl)^2}{ms^2kT_0}\left(\frac{T_0}{T}\right)^{1/2}\frac{\sigma}{\sigma_a},$$

and

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$$\frac{\sigma}{\sigma_0} = \frac{9\pi}{32}\left(\frac{\pi T_0}{T}\right)^{1/2}\frac{\gamma_3}{Q_0}\left[1 + \frac{\left(Q_1 - \frac{5}{2}Q_0\right)^2}{\left(\frac{\pi}{8}\right)^{1/2} Q_0 + Q_2 Q_0 - Q_1^2} + \dots\right],$$

with

$$Q_n \equiv \int_0^\infty x^{2n+1} Q(x) e^{-x^2} dx = \frac{\sqrt{\pi}}{4} n! + \frac{\sqrt{\pi}}{2}\gamma_3 \times$$

$$\times \left\{(n+2)! + (-1)^{n+1}\alpha_0 \alpha^{n+3} b N_0 e^{\frac{\alpha_\gamma}{2}} \frac{d^{n+1}}{d\alpha^{n+1}}\left[\frac{\mathrm{ch}\left(\frac{\alpha_0 - \alpha}{2}\right)}{\alpha} K_1\left(\frac{\alpha}{2}\right)\right]\right\}.$$

are obtained. These equations allow T to be obtained as a function of the applied field strength and of the parameters of the semiconductor. $K_1(\alpha/2)$ is a Bessel function. The definitions of the other quantities are to be taken from the previous papers mentioned above. There are 2 figures.

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B102/B104

The effect of an electric....

ASSOCIATION: Institut poluprovodnikov AN USSR (Institute of Semiconductors, AS UkrSSR). Institut fiziki AN USSR Kiyev (Institute of Physics AS UkrSSR, Kiyev)

SUBMITTED: November 15, 1961

Card 5/5

DYKMAN, I. M.; TOMCHUK, P.M.

Effect of electric field on the temperature of electrons, electrical conductivity and thermionic emission of semiconductors. Part 3: Thermionic emission. Fiz. tver tela 3 no.2:632-641 F '61. (MIRA 14:6)

1. Institut fiziki AN USSR, Kiyev.
(Thermionic emission)
(Semiconductors)

DYKMAN, I.M.; TOMCHUK, P.M.

Effect of an electric field on the electron temperature, electric conductivity, and thermoelectric emission of semiconductors. Fiz. tver.tela 3 no.7:1909-1919 Jl '61. (MIRA 14:8)

1. Institut poluprovodnikov AN USSR, Kiyev.
(Electric fields) (Semiconductors)

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S/181/61/003/002/045/050
B102/B201

AUTHORS: Dykman, I. M. and Tomchuk, P. M.

TITLE: Effect of an electric field upon the electron temperature, the electrical conductivity, and the thermionic emission of semiconductors. III. Thermionic emission

PERIODICAL: Fizika tverdogo tela, v. 3, no. 2, 1961, 632-641

TEXT: The present work is based upon the results given in chapter I of Ref. 1: FTT, Vol. 2, 2228, 1960, formulas and definitions being also taken in part from the said paper. It had already been shown there that in semiconductors displaying sufficiently high concentrations of the conduction electrons, the spherical-symmetrical part of the electron-distribution function, also if there is a relatively strong electric field, is a Maxwellian. The authors of the present paper were concerned with determining this spherical-symmetrical part of the distribution function of fast conduction electrons, and with examining the conditions under which the electron gas is heated by the electric field; criteria are formulated in this connection. The spherical-symmetrical part $f_0(x)$ of the electron

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distribution function is determined by proceeding from an equation obtained in I, in addition taking account of the interaction between electrons and optical phonons. This equation is then given with

$$\psi(x)\left[\frac{d\xi_0}{dx}+2x\xi_0(x)\right]+\beta_1\left[\frac{T_0}{T}\frac{d\xi_0}{dx}+2x\xi_0(x)\right]g_1^4(x)+$$
$$+\beta_0\left[\frac{\theta_0}{T}\left(N_0+\frac{1}{2}\right)\frac{d\xi_0}{dx}+2x\xi_0(x)\right]g_1^2(x)+2\beta_F x^3\xi_1(x)=0. \quad (3)$$

its solution reads $\xi_0(x) = \text{const}.e^{-\mathcal{F}(x)}$ (10) and the following equation is derived:

$$\mathcal{F}(x)=2\int\frac{\left[\psi(x)+\beta_1 g_1^4(x)+\beta_0 g_1^2(x)\right]x\,dx}{\psi(x)+\frac{T_0}{T}\beta_1 g_1^4(x)+\frac{\theta_0}{T}\left(N_0+\frac{1}{2}\right)\beta_0 g_1^2(x)+\beta_F\frac{x^6}{g_1^4(x)}}. \quad (11)$$

$\xi_1(x) = \frac{e_0F\mathcal{L}}{2kT}\frac{x^3}{g_1^4(x)}\frac{d\xi_0}{dx}$, where $1/\mathcal{L} = 1/l + 1/l_0$. The heating of the

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electron gas by the field F is described by

$$\frac{T}{T_0}=\frac{1}{2}\left[1-\frac{k\theta_0 l}{4ms^2 l_0(2N_0+1)}\right]+\frac{1}{2}\left\{\left[1+\frac{k\theta_0 l}{4ms^2 l_0(2N_0+1)}\right]^2+\right.$$
$$\left.+4\left[\frac{\theta_0}{2T_0}\operatorname{cth}\left(\frac{\theta_0}{2T_0}\right)-1\right]\frac{k\theta_0 l}{4ms^2 l_0(2N_0+1)}+\frac{(e_0F)^2 l\mathcal{L}}{3ms^2kT_0}\right\}^{1/2}. \qquad (14)$$

If $\Theta_0 \ll T_0$ (Θ_0 being the "temperature" of the optical phonon, determined from the relation $\hbar\omega_0 = k\Theta_0$, and T_0 the temperature of the crystal lattice) (14) will be simplified to

$$\frac{T}{T_0}=\frac{1}{2}\left[1-\frac{(k\theta_0)^2 l}{8ms^2kT_0l_0}\right]+\frac{1}{2}\left[\left(1+\frac{(k\theta_0)^2 l}{8ms^2kT_0l_0}\right)^2+\frac{(e_0F)^2 l\mathcal{L}}{3ms^2kT_0}\right]^{1/2}. \qquad (15)$$

As may be seen, the temperature of the electron gas first increases quadratically with growing F, and linearly afterwards. The inequality

$$\frac{T}{T_0}\leqslant\frac{1}{2}\left[1+\sqrt{1+\frac{(l_0F)^2 l\mathcal{L}}{3ms^2kT_0}}\right]. \qquad (16)$$

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is practically always satisfied (m, s, and l are the parameters of the semiconductor). The thermionic current

$I = e_0 n D^* \sqrt{kT/2\pi m} \int_0^{\infty} u \exp(-\mathfrak{F}(u+v))du$ is then calculated, where D denotes the mean penetrability of the potential barrier semiconductor - vacuum, $u = x^2$, $v = \varphi/kT$, φ is the external work function of the semiconductor. Two limit cases are considered in this connection: 1) the impact-ionization mechanism does not have any effect upon the value of I; 2) the impact-ionization mechanism is considerable. In the former case $(x_0^2/4 = \varepsilon_0 > u_1)$ the fast-electron distribution function is found to be approximately Maxwellian, with an electron temperature equalling the lattice temperature

$$I \simeq \frac{e_0 n D^* T_0^2}{T^{1/2}} \left(\frac{kT}{2\pi m}\right)^{1/2} C_1(v) e^{-\frac{\varphi}{kT_0}}, \qquad (29)$$

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Furthermore, $I/I_0 = (T_0/T)^{3/2}C_1(v)$, where I_0 is the equilibrium thermionic current. $I(T_0)$ and the energy distribution of the thermionic electrons almost equals the corresponding characteristics in equilibrium thermionic emission. In the second case $(x_0^2/4 = \varepsilon_0 < v)$, the formula

$$I \simeq \frac{e_0 n D^*}{\mu_1^2}\left(\frac{kT}{2\pi m}\right)^{1/2} C_1(\varepsilon_0)\, e^{-\varepsilon_0\left(\frac{T}{T_0}-\mu_1\right)}\left[1+\frac{\mu_1\mu_2^3}{4}(v^4-\varepsilon_0^4)\right] e^{-\frac{\mu_1\varphi}{kT}}. \quad (37)$$

obtained for I deviates from the Maxwellian shape considerably. Under certain conditions, above all if the electron temperature is higher than T_0 but lower than T (the electron gas temperature) $\varsigma(I)$ can be approached to the Maxwellian shape. With otherwise unvaried parameters, I is always larger for $\varepsilon_0 < v$ than for $\varepsilon_0 > v$. There are 5 references: 3 Soviet-bloc and 2 non-Soviet-bloc.

20147

Effect of an electric field ...

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ASSOCIATION: Institut fiziki AN USSR Kiyev (Institute of Physics AS UkrSSR, Kiyev)

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SUBMITTED: July 6, 1960

Card 6/6

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B102/B202

9.4,7700 (1138,1043,1158,1160)

AUTHORS: Dykman, I. M. and Tomchuk, P. M.

TITLE: Effect of an electric field on electron temperature, electrical conductivity, and thermionic emission of semiconductors. IV. Low lattice temperatures

PERIODICAL: Fizika tverdogo tela, v. 3, no. 7, 1961, 1909 - 1919

TEXT: The present paper was the subject of a lecture delivered on October 19, 1960 at the Fourth Conference on Semiconductor Theory, Tbilisi. This paper is the fourth in a series; the references to the previous papers read as follows: Ref. 1: FTT, II, 2228, 1960; Ref. 2: FTT, III, 3, 632, 1961; Ref. 3: FTT, III, 4, 1258, 1961. The authors generalize a method which has been developed in Ref. 1 so that it can be applied also to low temperatures where the scattering from impurities can no longer be neglected, and may even exceed the scattering from the lattice. The distribution function $\xi(x) = \xi_0(x) + \xi_1(x)\cos\vartheta$ of the conduction electrons in atomic semiconductors located in a homogeneous electric

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field F, was determined in Ref. 1 (x is the dimensionless electron momentum, $x = p/(2mkT)^{1/2}$). Neglecting the impurity scattering, the current j and the electron temperature T were calculated. At low temperatures or high field strengths, however, no agreement could be obtained between these results and the experimental ones. This is ascribed to the fact that neither impurity scattering nor electron heating by the field have been taken into account. The authors proceed from the kinetic equation $(\partial f/\partial t)_F + (\partial f/\partial t)_L + (\partial f/\partial t)_e + (\partial f/\partial t)_p = 0$ (consideration of the effect of field, lattice, electron collisions, and impurity scattering). It is assumed, however, that $T_0 \ll \Theta_0$ (Θ_0 Debye temperature) where $k\Theta_0 = \hbar\omega_0$, is the energy of an optical phonon. It is assumed that at T_0 the optical phonons are not thermally excited and hence are not absorbed by electrons. It is further assumed that the increase in electron temperature due to the field does not exceed Θ_0 and that the electrons produce no optical phonons. Hence, the interaction between electrons and optical phonons is neglected.

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Proceeding from these assumptions and using the expressions obtained in Ref. 1. as well as the quantities defined there, a number of relations is derived. E. g.,

$$\vartheta_1 \simeq 4\pi nkT \int \left(\frac{\partial f_0}{\partial t}\right)_L x^4 dx = \frac{4n^2e^4}{M_1}\left(\frac{2\pi m}{kT}\right)^{1/2}\left(1-\frac{T_0}{T}\right)\ln\left(\frac{h}{b_0}\right), \qquad (11)$$

is obtained for the energy transferred per unit volume per unit time (when the distributions of the electrons of temperature T and of the impurity ions of temperature T_o are Maxwellian).

$$\vartheta_2 = \frac{8ns^2T}{lT_o}\left(\frac{2mkT}{\pi}\right)^{1/2}\cdot\left(1-\frac{T_o}{T}\right) \quad (12) \text{ and } \quad \frac{\vartheta_1}{\vartheta_2} = \frac{\pi n l e^4}{2M_1 s^2 kT}\,\frac{T_o}{T}\,\ln\left(\frac{h}{b_o}\right) \ll 1 \qquad (13)$$

are obtained for the energy transferred by electrons. Besides, $\alpha_1 = \frac{4ms^2}{kT_o} < 1$, $\alpha_2 = 2s\left(\frac{3m}{kT_o}\frac{T}{T_o}\right)^{1/2} < 1$ and (13), the conditions $\lambda \ll n^{-1/3}$ and $\ln\frac{h}{b_o} = \ln\left(\frac{9k^3T^3}{4\pi ne^6}\right)^{1/2} \gg 2$ are obtained as further criteria for the

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applicability of the method of the kinetic equation. (λ is the Debye electron wavelength, h the Debye radius, $b_o = e^2/3kT$); the latter condition is that for the application of the Landau method. Furthermore, according to Ref. 10, the quantity γ_E characterizing the density of an ionized plasma, $\gamma_E = -\frac{\sqrt{\pi}}{6\gamma_2} J$, is calculated and found to be $\gamma_E = 0.578$ which is in good agreement with the value obtained in Ref. 10.

$$T = \frac{T_o}{2}\left[1 + \sqrt{1 + \frac{3\pi}{32}\frac{(e_oFl)^2}{ms^2kT_o}}\right] \quad (30)$$

is obtained for the electron temperature by proceeding from

$$\frac{T}{T_o}\left(\frac{T}{T_o} - 1\right) = \gamma_3 \gamma_E \frac{(e_oFl)^2}{ms^2kT_o} \quad (28).$$

The conduction current density is obtained from

$$j = \frac{4e_o^2FkT}{\pi e^4 \ln\frac{h}{b_o}}\left(\frac{2kT}{\pi m}\right)^{1/2}\gamma_E \quad (29)$$

as

$$j = \frac{8e^2Fnl_o}{(kT_o)^{3/2}}\left(\frac{2}{\pi m'}\right)^{1/2}\gamma_3\gamma_E \quad (35)$$

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where
$$\tau_3 = \frac{c_1 \tau^3}{\ln (c_2 \tau^{1/3})}, \quad (32)$$

$$c_1 = \frac{(kT_0)^3}{2\pi n l_0 e^4}; \; c_2 = 3\left(\frac{c_1 l_0}{2e^2}\right)^{1/3}. \quad (33)$$

Hence it was found that in the region of impurity scattering the electron interaction considerably influences not only the symmetrical part of the distribution function but also the antisymmetrical part; the change of the latter has to be taken into account when deriving the formulas. The authors thank V. N. Ponomarenko for assistance. There are 6 figures and 10 references: 6 Soviet-bloc and 4 non-Soviet-bloc. The most important references to English-language publications read as follows: Ref. 10: L. Spitzer a. R. Härm. Phys. Rev. 89, 977, 1953; Ref. 6: R. W. Keyes. J. Phys. Chem. Solids, 6, 1, 1958; Ref. 4: S. H. Koenig. J. Phys. Chem. Solids, 8, 227, 1959.

ASSOCIATION: Institut poluprovodnikov AN USSR Kiyev (Institute of Semiconductors AS UkrSSR, Kiyev)

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L 00448-67 EWT(m)/EWP(t)/ETI IJP(c) JD

ACC NR: AP6026727 SOURCE CODE: UR/0181/66/008/008/2511/2513

AUTHOR: Bondar, V. M.; Sarbey, O. G.; Tomchuk, P. M. 41

ORG: Physics Institute, AN UkrSSR, Kiev (Institut fiziki, AN UkrSSR) B

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TITLE: Dependence of the anisotropy of scattering of current carriers in n-Ge on the impurity concentration

SOURCE: Fizika tverdogo tela, v. 8, no. 8, 1966, 2511-2513

TOPIC TAGS: semiconductor carrier, germanium single crystal, carrier scattering

ABSTRACT: The anisotropy parameter $K = \mu_{\perp} / \mu_{\parallel}$ was measured at the liquid nitrogen temperature on single crystals of n-germanium doped with antimony. The carrier concentrations were between 3×10^{13} and 8×10^{17} cm^{-3}. Fig. 1 shows the measured anisotropy of mobility versus the carrier concentration in n-Ge. Curve 1 represents results obtained without considering interelectronic interaction, and curve 2 shows them with this interaction taken into account. With the exception of very high concentrations ($n \simeq 5 \times 10^{17}$ cm^{-3}), a good agreement was obtained between the experimental results and the curve calculated by allowing for the electron-electron interaction. The value of $\tau_{\parallel}^{(a)} / \tau_{\perp}^{(a)}$, which characterizes the anisotropy of the relaxation time for acoustic scattering, was found to be 1.52. Authors thank V. N. Vasilevskiy and A. N. Kvasnitskaya for supplying certain germanium samples and V. M. Vsetskiy for his assist-

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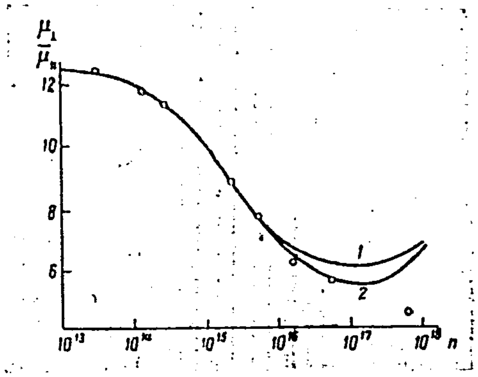
ACC NR: AP6026727

ance in the measurements. Orig. art. has: 1 figure.

Fig. 1



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AUTHOR: Tomchuk, P. M.

TITLE: Effect of an electric field on the electron temperature, electrical conductivity, and thermionic emission of semiconductors

PERIODICAL: Fizika tverdogo tela, v. 3, no. 4, 1961, 1019-1030

TEXT: The author, together with I. M. Dykman (FTT II, 2228, 1960), has already investigated the effect of an electric field on the distribution and temperature of an electron gas in a semiconductor, taking account of the Coulomb interaction among the electrons. It was found that for sufficiently high electron concentrations, the distribution remains Maxwellian even in relatively strong fields if the temperature is different from the lattice temperature. In the temperature range considered (above the Debye temperature), the conductivity of the electron gas is determined chiefly by the thermal vibrations of the lattice. The electron interaction as well as the scattering by ionized impurities are found to be unimportant for the velocity distribution in this temperature

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range. The role of scattering by impurities increases at lower temperatures, and at sufficiently low temperatures it predominates over over the scattering by lattice vibrations. The relative number of short-range electron collisions and the role of scattering by plasma oscillations are expected to increase at lower temperatures. These problems were not studied in the earlier paper; they have been exhaustively studied in the present one. While in the case of a plasma, short-range collisions and the interaction with plasma oscillations are negligible, this is not so with a semiconductor. This is because the electron concentration in a real semiconductor is 10^2 to 10^3 times that in a plasma, and the electron temperature is lower. For a plasma, $\ln(h/b_0)$ is of the order of 10, and the reciprocal can be neglected; for the semiconductor it is 2-5, and $1/\ln(h/b_0)$ can no more be treated as a small parameter ($b_0 = e^2/3kT$). Now, the effect of considering plasma oscillations and short-range collisions (i.e. when terms of the order of $1/\ln(h/b_0)$ are considered) on the distribution function and the conductivity of the electron gas is investigated. To simplify the problem, the electron scattering by lattice vibrations is neglected but that by impurities is considered. The problem is equivalent to that of a completely ionized plasma for which the electron distribution

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function f($\vec{v}$) is sought. f($\vec{v}$) is the solution of the kinetic equation:

$$\frac{df}{dt}=\left(\frac{\partial f}{\partial t}\right)_F+\left(\frac{\partial f}{\partial t}\right)_e+\left(\frac{\partial f}{\partial t}\right)_{\mathcal{F}}+\left(\frac{\partial f}{\partial t}\right)_W=0. \quad (1)$$

which takes into account the effect of the field (F ∥ z), the interelectronic interaction (e), the ionized impurities ($\mathcal{F}$), and the plasma oscillations (W). Its solution is to be sought in the form

$$\left.\begin{array}{l} f(\mathbf{v})=f_0(v)+\cos\vartheta f_1(v)=f_0(v)\{1+v_z D(v)\}, \\ \cos\vartheta=\frac{v_z}{v},\ f_1(v)=vD(v)f_0(v). \end{array}\right\} \quad (2)$$

One obtains

$$\left(\frac{\partial f}{\partial t}\right)_{\mathcal{F}}=-B\sum_{j,k=1}^{3}\frac{\partial}{\partial p_j}\left\{\int\limits_{\mathbf{v}'=0}^{\infty}\left(\frac{f(\mathbf{v})}{M}\frac{\partial\varphi(\mathbf{v}')}{\partial v_k'}-\frac{\varphi(\mathbf{v}')}{m}\frac{\partial f(\mathbf{v})}{\partial v_k}\right)\frac{\partial^2|\mathbf{v}-\mathbf{v}'|}{\partial v_j\partial v_k}d\mathbf{v}'\right\}-$$
$$-\int\limits_{\mathbf{v}_i=0}^{\infty}\int\limits_{\epsilon=0}^{2\pi}\int\limits_{b=0}^{b_0}(f(\mathbf{v})\varphi(\mathbf{v}_i)-f(\mathbf{v}')\varphi(\mathbf{v}_i'))\,gb\,db\,d\epsilon\,d\mathbf{v}_i. \quad (3)$$

where $B = 2\pi e^4 \ln(h/b_0)$; M - ion mass, m - electron mass, $\varphi(v)$ - ion distribution function; $\vec{v}_i$, $\vec{v}$ and $\vec{v}_i'$, $\vec{v}'$ - ion and electron velocities before and

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after collisions, respectively; $\vec{g}$ - their relative velocity, ε - polar angle in the plane perpendicular to $\vec{g}$. The first part in (3) takes account of the long-range interactions (small collision angles), and the second part of the short-range interactions (large angles). To obtain $(\partial f/\partial t)_e$ it is sufficient to substitute φ, M, and $\vec{v}_i$ in (3) by f, m, and $\vec{v}_e$, respectively. The term $(\partial f/\partial t)_F$ has the usual form. The last term of (1) is given by

$$\left(\frac{\partial f}{\partial t}\right)_W=\int W\{[f(\mathbf{p}+\hbar\mathbf{q})(N_\omega+1)-f(\mathbf{p})N_\omega]\delta(\mathcal{E}_\mathbf{p}-\mathcal{E}_{\mathbf{p}+\hbar\mathbf{q}}+\hbar\omega)+ + [f(\mathbf{p}-\hbar\mathbf{q})N_\omega-f(\mathbf{p})(N_\omega+1)]\delta(\mathcal{E}_\mathbf{p}-\mathcal{E}_{\mathbf{p}-\hbar\mathbf{q}}-\hbar\omega)\}\,d\mathbf{q}. \quad (4)$$

where $\bar{\mathcal{E}}\gg\hbar\omega$ ($\hbar\omega$ - energy of a quantum of plasma oscillation, $\bar{\mathcal{E}}$ - average electron energy). For Ge $\bar{\mathcal{E}}\gg\hbar\omega$ is satisfied, for example, at 100°K and $n = 10^{16}\,\mathrm{cm}^{-3}$. $\vec{p}$ is the electron momentum, $\vec{q}$ the wave vector of the plasma wave; $W = W_e = 2ne^4/m\omega q^2$ for collisions of electrons with electronic plasma oscillations. For collisions with ionic plasma oscillations $W=W_i=\frac{2ne^4}{M\Omega q^2}\left(\frac{\hbar^2q^2}{1+\hbar^2q^2}\right)$, where ω and Ω indicate the electronic and the ionic

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plasma frequencies, respectively. One obtains $\left(\frac{\partial f_1}{\partial t}\right)_W = -\frac{f_1(v)}{\tau} = -\left(\frac{1}{\tau_e} + \frac{1}{\tau_i}\right) f_1(v)$; $\frac{1}{\tau_e} = \frac{\pi\hbar}{p^3} m \int\limits_{q_{min}}^{q_{max}} W_e q^3 (2N_\omega + 1) dq$. Next, the asymmetric part of the distribution function is studied. With

$$\cos\chi = \frac{u^2 - 1}{u^2 + 1}, \quad u = \frac{b g^2 \mu}{e^2} = \frac{b}{b_0}, \quad \mu = \frac{mM}{m + M} \simeq m. \qquad (15),$$

$$\int\limits_{b=0}^{b_0} (1 - \cos\chi)\, b\, db = \left(\frac{e^2}{mv^2}\right)^2 \ln 2. \qquad (16)$$

and after introducing the dimensionless coordinates

$$\left.\begin{aligned} &x = v\sqrt{\alpha_1}, \quad c = v\sqrt{\alpha_1}, \quad (c = x), \\ &\xi_1(x) = \frac{1}{n}\left(\frac{\pi}{\alpha_1}\right)^{3/2} f_1(x), \quad \alpha_1^2 = \frac{m}{2kT}, \\ &\eta(x) = \alpha_1^{-1/2} D(x), \quad \xi_1(x) = x\eta(x) e^{-x^2}. \end{aligned}\right\} \qquad (17)$$

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the equation for the asymmetric part $\xi_1(x)$ of the distribution function is obtained in the form

$$\psi(x)\left\{\xi_1'(x)+\left(2x-\frac{1}{x}\right)\xi_1(x)+4\int_x^\infty \xi_1(x)\,dx\right\}+$$
$$+e^{-x^2}\left\{-\frac{4}{5}\left(\int_0^x \xi_1(x)\,x^4dx+x^5\int_x^\infty \xi_1(x)\,dx\right)+\right.$$
$$\left.+\frac{2}{3}\left(\int_0^x \xi_1(x)\,x^2dx-2x^3\int_x^\infty \xi_1(x)\,dx\right)\right\}+$$
$$+\frac{m^2}{(4\pi)^2 a_1^{1/2}B}N(\eta)=\int_0^x Q(x)\,\xi_1(x)\,dx+\gamma_2\int_0^x e^{-x^2}x^4dx. \quad (18).$$

$$N(\eta)=\int_{c_1=0}^{x}\int_{c_2=0}^{\infty}\int_{\varepsilon=0}^{2\pi}\int_{b=0}^{b_0} c_1\left[c_1'\eta(c_1')+c_2'\eta(c_2')-c_1\eta(c_1)-\right.$$
$$\left.-c_2\eta(c_2)\right]e^{-c_1^2-c_2^2}g\,b\,db\,d\varepsilon\,dc_1\,dc_2, \quad (19)$$

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$$Q(x)=\frac{\sqrt{\pi}}{2}\left\{1+\lambda\ln 2+\frac{\lambda}{3}(\ln 4+\gamma(x))\right\}=$$
$$=\frac{\sqrt{\pi}}{2}\left\{1+\lambda\left(\ln 2^{4/3}+\frac{1}{3}\gamma(x)\right)\right\}, \tag{20}$$

$$\lambda=\frac{1}{\ln\left(\frac{h}{b_0}\right)^2},\quad \gamma(x)=\begin{cases}\ln 4\left(1-\frac{3}{2x^2}\right), & x^2>2,\\ 0, & x^2<2,\end{cases} \tag{21}$$

$$\left.\begin{aligned}\xi_1(x)&=Cxe^{-x^2}+xe^{-x^2}\int_0^x\frac{y(x)}{x}e^{x^2}dx,\\ y(x)&=\xi_1'(x)+\left(2x-\frac{1}{x}\right)\xi_1(x),\end{aligned}\right\}(22), \tag{22}$$

$$C=-\frac{3\sqrt{\pi}}{8G(0)}\gamma_2-\frac{1}{G(0)}\int_0^\infty Q(x)e^{-x^2}xdx\int_0^x\frac{y(t)}{t}e^{t^2}dt, \tag{24}$$

$$G(x)=\int_x^\infty Q(x)e^{-x^2}xdx. \tag{25}$$

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finally lead to

$$\varphi(x)\,y(x)+2e^{-x^2}\left[\int_0^x\left\{\varphi(t)\,e^{t^2}-\left(\frac{t^5}{5}+\frac{t^3}{3}\right)\right\}\frac{y(t)}{t}\,dt+\right.$$

$$\left.+\int_x^\infty\left\{\varphi(x)\,e^{x^2}-\left(\frac{x^5}{5}+\frac{x^3}{3}\right)\right\}\frac{y(t)}{t}\,dt\right]+\frac{m^2}{(4\pi)^2 a_1^{1/2} B}N(\eta)+\int_0^x G(x)\frac{y(t)}{t}e^{t^2}\,dt+$$

$$+\int_x^\infty G(t)\frac{y(t)}{t}e^{t^2}\,dt-\frac{1}{G(0)}\int_0^\infty G(x)\,G(t)\frac{y(t)}{t}e^{t^2}\,dt=$$

$$=\gamma_2\left(\frac{3\sqrt{\pi}}{8G(0)}G(x)-\int_x^\infty e^{-x^2}x^4\,dx\right), \qquad (26)$$

and the solution reads

$$\xi_1(x)=xe^{-x^2}\eta(x)=x\left\{C+\frac{1}{2}a_1x^2+\frac{1}{4}a_2x^4+\frac{1}{6}a_3x^6+\dots\right\}e^{-x^2}. \qquad (27)$$

The moments are calculated in the next section. With the conditional equations

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$$S_{3/2}^{(n)}(x) = \frac{1}{n!} x^{-3/2} e^{x} \frac{d^n}{dx^n} \left(x^{3/2+n} e^{-x}\right). \tag{32}$$

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$$\Upsilon_{nm} = \pi^{-3} \int_{c_1=0}^{\infty} \int_{c_2=0}^{\infty} \int_{\varepsilon=0}^{2\pi} \int_{b=0}^{b_0} c_1^{2n} c_1 \left[c_1' c_1'^{2m} + c_2 c_2'^{2m} - \right.$$

$$\left. - c_1 c_1^{2m} - c_2 c_2^{2m}\right] e^{-c_1^2 - c_2^2} g b\, db\, d\varepsilon\, dc_1\, dc_2 \tag{33}$$

one obtains

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$$\left.\begin{array}{c}\gamma_{00}=0,\ \gamma_{11}=4\Omega^{(2)}(2),\ \gamma_{12}=14\Omega^{(2)}(2)+4\Omega^{(2)}(3),\\ \gamma_{22}=77\Omega^{(2)}(2)+28\Omega^{(2)}(3)+4\Omega^{(2)}(4),\\ \gamma_{13}=\frac{189}{4}\Omega^{(2)}(2)+27\Omega^{(2)}(3)+3\Omega^{(2)}(4),\\ \gamma_{23}=\frac{2835}{8}\Omega^{(2)}(2)+\frac{783}{4}\Omega^{(2)}(3)+\frac{75}{2}\Omega^{(2)}(4)+3\Omega^{(2)}(5),\\ \gamma_{33}=\frac{130977}{64}\Omega^{(2)}(2)+\frac{10935}{8}\Omega^{(2)}(3)+\frac{2817}{8}\Omega^{(2)}(4)+\\ +6\Omega^{(4)}(4)+\frac{81}{2}\Omega^{(2)}(5)+\frac{9}{4}\Omega^{(2)}(6),\end{array}\right\} \quad (34)$$

$(\gamma_{nm} = \gamma_{mn})$ and

$$\left.\begin{array}{c}\Omega^{(l)}(r)=\pi^{1/2}\int\limits_0^\infty e^{-g^2}g^{2r+1}\Phi^{(l)}dg\\ \Phi^{(l)}=\int(1-\cos^l\chi)\,gbdb.\end{array}\right\} \quad (35).$$

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The electrical conductivity of the electron gas is found to be

$$\sigma = \frac{2m}{e^2 \ln\left(\frac{h}{b_0}\right)} \left(\frac{2kT}{\pi m}\right)^{3/2} \gamma_E \quad \text{with} \quad \gamma_E = -\frac{\sqrt{\pi}}{6\sqrt{2}} \int_0^\infty \xi_1(x) x^3 dx.$$

Substituting (27) in (40) and considering

$$\left.\begin{aligned}
a_1 &= -\frac{\gamma_2}{\Delta}(12.417 + 51.155\lambda + 78.712\lambda^2 + 54.996\lambda^3 + \\
&\quad + 16.824\lambda^4 + 1.8309\lambda^5), \\
a_2 &= \frac{\gamma_2}{\Delta}(2.8386 + 11.062\lambda + 15.547\lambda^2 + 9.212\lambda^3 + \\
&\quad + 1.984\lambda^4 + 0.10397\lambda^5), \\
a_3 &= -\frac{\gamma_2}{\Delta}(0.29990 + 1.2046\lambda + 1.7765\lambda^2 + 1.1500\lambda^3 + \\
&\quad + 0.30318\lambda^4 + 0.02587\lambda^5), \\
\Delta &= 4.2831 + 21.488\lambda + 43.330\lambda^2 + 44.007\lambda^3 + \\
&\quad + 16.794\lambda^4 + 6.3967\lambda^5 + 0.6627\lambda^6.
\end{aligned}\right\} \quad (38)$$

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one finds
$$\gamma_E = \frac{18.92 + 98.54\,\lambda + 206.7\,\lambda^2 + 220.1\,\lambda^3 + 109.1\,\lambda^4 + 35.13\,\lambda^5 + 3.784\,\lambda^6}{32.72 + 202.8\,\lambda + 524.8\,\lambda^2 + 727.0\,\lambda^3 + 525.2\,\lambda^4 + 200.4\,\lambda^5 + 62.76\,\lambda^6 + 5.977\,\lambda^7}. \quad (41)$$

If ionic oscillations are absent or negligibly small, the coefficients a_i are somewhat different and
$$\gamma_E = \frac{28.87 + 135.0\,\lambda + 246.3\,\lambda^2 + 227.7\,\lambda^3 + 113.1\,\lambda^4 + 28.65\,\lambda^5 + 2.882\,\lambda^6}{49.92 + 273.6\,\lambda + 604.1\,\lambda^2 + 706.3\,\lambda^3 + 475.5\,\lambda^4 + 184.8\,\lambda^5 + 30.84\,\lambda^6 + 3.290\,\lambda^7}. \quad (42)$$

In general, one obtains $\gamma_E^0 = 0.578$ for $\lambda \ll 1$. If ionic plasma oscillations are neglected, the approximate value is $\sigma \simeq 1.75 \frac{2m}{e^2}\left(\frac{2kT}{\pi m}\right)^{3/2}$ and $\sigma \simeq 1.16 \frac{2m}{e^2}\left(\frac{2kT}{\pi m}\right)^{3/2}$, if such oscillations are considered. The applicability of L. D. Landau's method is also discussed. The symbols used here have been adapted to the international symbols (see L. Spitzer, R. Hörm, Phys. Rev. 89, 977, 1953; R. Stratton, Proc. Roy. Soc. 242, 355, 1957; Cohen, Spitzer, Roytly, Phys. Rev. 80, 230, 1960; P. Pines, Physica, decl. 26, 103, 1960. There are 9 references: 4 Soviet-bloc and 5 non-Soviet-bloc.

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ASSOCIATION: Institut fiziki AN USSR Kiyev (Institute of Physics, AS UkrSSR, Kiyev)

SUBMITTED: April 29, 1960

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DYKMAN, I.M.; TOMCHUK, P.M.

Effect of an electric field on electron temperature, electroconductivity and thermionic emission of semiconductors. Part 1: Atomic semiconductors. Development of the method. Fiz. tver. tela 2 no.9:2228-2239 S '60. (MIRA 13:10)

1. Institut fiziki AN USSR, Kiyev.
(Semiconductors)
(Electric fields)

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AUTHORS: Dykman, I. M., Tomchuk, P. M.

TITLE: The Effect of the Electric Field Upon Electron Temperature, Electrical Conductivity, and the Thermionic Emission of Semiconductors. I. Atomic Semiconductors. Development of the Method

PERIODICAL: Fizika tverdogo tela, 1960, Vol. 2, No. 9, pp. 2228-2239

TEXT: An investigation is carried out of an atomic, unbounded, homogeneous semiconductor with constant electron concentration n in the conductance band, with quadratic dispersion law $\mathcal{E} = p^2/m$ ($\mathcal{E}$ = energy, p = pulse, m = mass of the electron). A field F is applied to the semiconductor in the direction of the z-axis. The distribution function $\int f(\vec{p})d\vec{p} = n$ (1) in the steady state is obtained from the kinetic equation: $\partial f/\partial t = (\partial f/\partial t)_F + (\partial f/\partial t)_{\mathcal{L}} + (\partial f/\partial t)_e + (\partial f/\partial t)_{\mathcal{P}} = 0$ (2), which expresses the change in $f(\vec{p})$ under the action of the field F, the lattice vibration $\mathcal{L}$, the electron interactions e, and the scattering $\mathcal{P}$ by impurity ions.

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B004/B056

The Effect of the Electric Field Upon Electron Temperature, Electrical Conductivity, and the Thermionic Emission of Semiconductors. I. Atomic Semiconductors. Development of the Method

Equation (2) is solved by expansion in Legendre polynomials: $f(\vec{p}) = f_o(p) + \cos\vartheta f_1(p)$; $(\cos\vartheta = p_z/p)$ (3). For the individual terms of (2), the expressions (4), (5), (7), (12) are written down, substituted into (2), and thereby the system of equations: $(8\pi Bm/p^2)L\left[f_o(p), f_o(p)\right] + \left\{(s^2/lkT_o)(g^4/p^2)\left[f_o + (mkT_o/p)(df_o/dp\right]\right\} + (1/3)e_oFf_1 = 0$ (16) and $8\pi BmM\left[f_o(p), f_1(p)\right] - 2Bmn(f_1/p^3) - (g^4/lmp^3).f_1 + e_oF(\partial f_o/\partial p) = 0$ (17) is obtained. B,L,M are defined by equations (8) and (11). By substituting the variables $x = p\sqrt{\alpha}$, $\varphi_o(x) = (1/D)f_o(p)$, $\varphi_1(x) = (1/D)f_1(p)$ (19) as well as $\alpha = (2mkT)^{-1}$, $D = n(\alpha/\pi)^{3/2}$ (20), the equation $(1/x^2)L\left[\varphi_o(x), \varphi_o(x)\right] + \beta_1(g_1^4/x^2).\left[\varphi_o(x) + (1/2x)(T_o/T)(d\varphi_o/dx)\right] + \beta_2\varphi_1(x) = 0$ (21) is obtained. Neglect of the terms with β_1, β_2 in (21) leads to the Maxwell function $\varphi_o(x) = \exp(-x^2)$ (23). The parameter T expresses the electron temperature.

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The Effect of the Electric Field Upon Electron Temperature, Electrical Conductivity, and the Thermionic Emission of Semiconductors. I. Atomic Semiconductors. Development of the Method

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Substitution of (23) in (17) and introduction of the coordinates (19) lead to equation (25), integration to equation (27), and, at $x \longrightarrow \infty$, to equation (29), after which finally $\xi_1(x) = Cx \exp(-x^2) + x \exp(-x^2) \cdot \int_0^x [y(x)/x] \exp(x^2)dx$ (31) is found. As a final result, the following is given for the electron temperature: $T \simeq (T_o/2)\left[1 + \sqrt{1 + (3\pi/32)(e_oFl)^2/ms^2kT_o}\right.$ (43); and for the conduction current: $j = (3n/16)e_o^2Fl\sqrt{2\pi/mkT}$ (44). The authors enumerate the conditions under which, according to their opinion, their method may be used also to determine the distribution function of electrons in a plasma. They mention B. I. Davydov and I. M. Shmushkevich (Ref. 1), S. I. Levitin (Ref. 4), V. L. Ginzburg and V. P. Shabanskiy (Ref. 5), and L. D. Landau (Ref. 12). There are 15 references: 7 Soviet, 4 US, 3 British, 2 Japanese, and 1 German.

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The Effect of the Electric Field Upon Electron Temperature, Electrical Conductivity, and the Thermionic Emission of Semiconductors. I. Atomic Semiconductors. Development of the Method

S/181/60/002/009/028/036
B004/B056

ASSOCIATION: Institut fiziki AN USSR, Kiyev (Institute of Physics of the AS UkrSSR, Kiyev)

SUBMITTED: January 5, 1960

Card 4/4

TOMCHUK, P.M.

Effect of an electric field on the electric field on the electron temperature, conductance and thermianic emission of semiconductors. Part 2: Taking plasma oscillations and short-range collisions into account. Fiz.tver.tela 3 no.4:1019-1030 Ap '61. (MIRA 14:4)

1. Institut fiziki AN USSR, Kiyev.
(Semiconductors--Electric properties) (Electric fields)

TOMCHUK, P.M.

Variation method of determining electroconductivity, taking the Coulomb interaction of carriers into account. Fiz.tver.tela 3 no.4:1258-1267 Ap '61. (MIRA 14:4)

1. Insitut fiziki AN USSR, Kiyev.
(Electron gas) (Semiconductors) (Plasma (Ionized gases))

VINETSKIY, V.L.; MASHKEVICH, V.S.; TOMCHUK, P.M.

Theory of stationary induced radiation in band-band transitions. Fiz. tver. tela 6 no.7:2037-2046 Jl '64. (MIRA 17:10)

1. Institut fiziki AN UkrSSR, Kiyev.

ACC NR: AP7001:33 SOURCE CODE: UR/0048/66/030/012/1927/1929

AUTHOR: Grigor'yev, N.N.; Dykman, I.M.; Tomchuk, P.M.

ORG: none

TITLE: Emission of hot electrons from a polar semiconductor having a nonparabolic dispersion law [Report Twelfth All-Union Conference on the Physical Fundamentals of Cathode Electronics held at Leningrad, 22 - 26 Oct. 1965]

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v. 30, no. 12, 1966, 1927-1929

TOPIC TAGS: thermionic emission, electron emission, electric field, semiconducting material, indium compound, antimonide, mathematic physics

ABSTRACT: The authors discuss thermo-electron emission from a polar semiconductor in which the carriers have been heated by an applied electric field. An approximate expression for the electron energy distribution in such a semiconductor is written but not derived. This expression is valid for an arbitrary dispersion law relating the electron energy E and momentum p, and in addition to its dependence on the dispersion law it depends on the lattice temperature, the optical phonon temperature, and the ratio F/F_0 of the electric field strength F to a certain field strength F_0 that was introduced by H. Fröhlich and B.V. Paranjape (Proc. Phys. Soc. B69, 21 (1956)) and has a value of some 300 or 400 V/cm for InSb. This distribution function was employed to calculate the thermo-electron emission current for the case when the dis-

ACC NR: AP7001722

persion law is $p^2/2m = E(E + E/G)$, where m is the effective mass of the electron at the bottom of the band and G is the energy width of the forbidden gap. This dispersion law is believed to be valid for InSb. It is found that when the work function is greater than theo forbidden gap width, the nonparabolicity of the dispersion law results in an appreciable increase of the Richardson current. The application of an electric field greatly increases the thermo-electron emission current over the Richardson value. This is illustrated by a curve showing the thermo-electron emission current as a function of the applied electric field, the curve being calculated with parameter values appropriate to InSb with a reduced work function of 1.1 eV. An electric field of strength F_0 increases the emission by several orders of magnitude over the no field (Richardson) value, and with fields that might be achieved by pulsing, the emission could be enhanced by as much as 10 orders of magnitude. Orig. art. has: 5 formulas and 1 figure.

SUB CODE: 20 SUBM DATE: None ORIG. REF: 005 OTH REF: 001

TOMCHUK, V.S., inzh.; KVASKOV, A.P., doktor tekhn.nauk

Conditions of separating mineral particles in heavy suspension in a hydraulic cyclone. Izv. vys. ucheb. zav.; gor. zhur. 5 no.3:154-158 '62. (MIRA 15:7)

1. Ural'skoye otdeleniye Vsesoyuznogo nauchno-issledovatel'skogo instituta mekhanicheskoy obrabotki poleznykh iskopayemykh.
(Separators (Machines))

AKHIYEZER, N.I.; TOMCHUK, Yu.Ya.

Theory of orthogonal polynomials over several intervals. Dokl.AN SSSR 138 no.4:743-746 Je '61. (MIRA 14:5)

1. Khar'kovskiy gosudarstvennyy universitet imeni A.M.Gor'kogo. Predstavleno akademikom S.N.Bernshteynom.
(Functions, Orthogonal)

ACC NR: AP6015449 (N) SOURCE CODE: UR/0181/66/008/005/1343/1350

48

B

AUTHOR: Dykman, I. M.; Tomchuk, P. M.

ORG: Institute of Semiconductors, AN UkrSSR, Kiev (Institut poluprovodnikov AN UkrSSR); Institute of Physics, AN UkrSSR, Kiev (Institut fiziki AN UkrSSR)

TITLE: Function of electron distribution and mobility in polar semiconductors with a nonparabolic dispersion law

SOURCE: Fizika tverdogo tela, v. 8, no. 5, 1966, 1343-1350

TOPIC TAGS: electron distribution, electron mobility, electron temperature

ABSTRACT: A donor-type polar semiconductor for which a nonparabolic dispersion law holds is investigated. The interaction is considered between the conducting electrons and the polar lattice vibrations, whose energy quanta are constant $\hbar\omega_0 = k\theta$. It is assumed that the lattice temperature $T_0 \gg 0$; it is shown that the "electron escape" effect is removed if the effective mass of the electrons grows with energy ε. For fast electrons, ε and the impulse p are related by the approximation $\varepsilon=\lambda p^{\nu}$, where $\nu < 4/3$. With a dispersion law such as is valid for InSb, the electron temperature increases monotonically with the function field. The instability of the solution for fields $F > F^*$ is removed, and thereby breakdown cannot occur. Conductivity and mobility differ from those when dispersion follows a parabolic law. Mobility falls as the

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field intensifies because the mean electron mass increases with their temperature. Curves are plotted for the dependence of the electron temperature in InSb and the relative conductivity on the strength of the applied field. Orig. art. has: 2 figures, 33 formulas.

SUB CODE: 20, ~~09~~/ SUBM DATE: 29Jul65/ ORIG REF: 006/ OTH REF: 004

awm

ACCESSION NR: AT4042330 S/3050/64/135/000/0093/0128

AUTHOR: Tomchuk, Yu. Ya.

TITLE: Orthogonal polynomials on a system of intervals of the real axis

SOURCE: Kharkov. Universitet. Ucheny*ye zapiski, v. 135, 1964. Zapiski mekhaniko-matematicheskogo fakul-teta i Khar'kovskogo matematicheskogo obshchestva (Notes of the Faculty of Mechanics and Mathematics and of the Kharkov Mathematical Society), v.29, Series 4, 1963, 93-128

TOPIC TAGS: abelian function, boundary problem, applied mathematics, dirichlet problem, linear system, orthogonal function, orthogonal polynomial, weighted function, Reimann integral, characteristic function

ABSTRACT: Classical systems of orthogonal polynomials are constructed for weighted functions, which in each interval of orthogonality are distinct from zero. Furthermore, those cases in which a weighted function vanishes only at a finite number of points are considered indispensable in contemporary general theories. In particular, the well-known asymptotic formula of S. N. Bernstein was derived for the case in which the weighted function, in general, does not vanish. Until recently there were no general constructions relating to the case in which a weighted function does not vanish on the whole interval

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lying within the interval of orthogonality. The present paper is devoted to this problem. For the construction and investigation of orthogonal polynomials on a system of intervals, one has to solve several theoretical and functional problems on two-sheeted Reimann surfaces. The author first discusses the transfinite diameter of the set E. Consider the function

$$h(z) = \exp \int_{\xi}^{z} \frac{M(z)}{\sqrt{R(z)}} dz, \qquad (1)$$

where M(z) is a polynomial of degree ρ with leading coefficient equal to one. Choose the remaining coefficients so that

$$\int_{a_k}^{b_k} \frac{M(z)}{\sqrt{R(z)}} dz = 0 \quad (k = 1, 2, \ldots p). \qquad (2)$$

These conditions introduce a system of ρ non-homogenoous, linear, algebraic equations. One can immediately show that the determinate of this system is different from zero. In addition, one can prove that the homogeneous system

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$$\int_{a_k}^{b_k} \frac{P(z)}{\sqrt{R(z)}}\, dz = 0 \quad (k = 1, 2, \ldots \rho), \tag{3}$$

where P(z) is a polynomial of degree ρ-1 with unknown coefficients, has only a trivial solution. The author next considers Abelian integrals. The function

$$\omega(z) = \int_{1}^{z} \frac{M(\zeta)}{\sqrt{R(\zeta)}}\, d\zeta, \tag{4}$$

which enters as an exponent in h(z), is an Abelian integral of the third order and has, on the Reimann surface $\mathfrak{S}$, two special logarithmic features, namely, at the point $z = \rho$, where $\omega(z)$ is represented as ln z, and at the point $z = \sigma'$, where $\omega(z)$ is represented as -ln z. The integral $\omega(z)$ is fixed so that its coefficients of periodicity

$$a_k = \oint_{C_k} d\omega(z) = 2\int_{a_k}^{b_k} \frac{M(\zeta)}{\sqrt{R(\zeta)}}\, d\zeta, \tag{5}$$

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are equal to zero. In addition to the function h(z) the author subsequently considers the function h(z;c), defined in the following way:

$$h(z;c)=\exp\omega(z;c)=\exp\frac{1}{2}\int\frac{1}{\sqrt{R(z)}}\left(\frac{\sqrt{R(z)}+\sqrt{R(c)}}{z-c}+M_c(z)\right)dz, \qquad (6)$$

where M_c (z) is a polynomial of degree ς with leading coefficient equal to one. After a discussion of the selection of the remaining coefficients, the author solves the system of ς linear equations in such a way that the determinant of the system coincides with the determinant of system (2). Finally, the author considers the boundary problem. A discussion of the Dirichlet problem follows, with certain special representations of the problem attributable to the boundary conditions. Orig. art. has: 200 formulas and 1 table.

ASSOCIATION: Mekhaniko-matematicheskiy fakul'tet, Khar'kovskiy gosudarstvenny*y universitat im. A.M. Gor'kogo, Khar'kov (Department of Mechanics and Mathematics, Khar'kov State University)

SUBMITTED: 00 ENCL: 00

SUB CODE: MA NO REF SOV: 004 OTHER: 000

Card 4/4

S/020/61/138/004/001/023
C111/C333

AUTHORS: Akhiyezer, N.I.,
Tomchuk, Yu. Ya.

TITLE: On the theory of orthogonal polynomials over several intervals

PERIODICAL: Akademiya nauk SSSR. Doklady, v. 138, no.4, 1961, 743-746

TEXT: The paper is a continuation of a paper of N.I. Akhiyezer (Ref.1: DAN, 134, no.1(1960)) and deals with the investigation of polynomials which are orthogonal on the interval system E

$$[-1, \alpha_1], \quad [\beta_1, \alpha_2], \quad \ldots, \quad [\beta_\varsigma, 1].$$

Let $\mathcal{G}$ denote the z-plane which is cut open along E, $\mathcal{G}'$ a second sample of $\mathcal{G}$, $\mathcal{F}$ the Riemannian surface formed by $\mathcal{G}$ and $\mathcal{G}'$, c - - point of $\mathcal{G}$, c' the subjacent point of $\mathcal{G}'$, $S(z) = (z - \alpha_1)(z - \alpha_2)\ldots(z - \alpha_\varsigma)$, $\sqrt{R(z)} = \sqrt{(z+1)(z-\alpha_1)(z-\beta_1)\ldots(z-1)}$. Let $T_n(x;t)$, $U_n(x;t)$ be polynomials of n-th degree with coefficients 1 for the highest terms which

which are orthogonal relative to the weights $\frac{S(x)}{\sqrt{-R(x)}}\frac{1}{t(x)}$, $\frac{\sqrt{-R(x)}}{S(x)}\frac{1}{t(x)}$ $(x \in E)$.

In (Ref. 1) the function $p(z,\sqrt{R(z)}) = T_n(z;P) - \frac{\sqrt{R(z)}}{S(z)} U_{n+1}(z;P)$ was considered, where $P(z)$ is a polynomial of even degree $p<n$ which is positive on E. It was shown that all poles and all zeros except ϱ distinguished ones are known in advance. Now it is assumed that $P(z)$ is positive on $[-1, +1]$. Then the distinguished zeros of $p(z,\sqrt{R(z)})$ lie in the intervals $[\alpha_k, \beta_k]$ each. Let $\gamma_1, \gamma_2, \ldots, \gamma_\lambda$ be the zeros on $\mathfrak{O}$ and $\gamma'_{\lambda+1}, \gamma'_{\lambda+2}, \ldots, \gamma'_\varrho$ the zeros on $\mathfrak{O}'$. Let $a_1, a_2, \ldots a_p$ be points of $\mathfrak{O}$ in which $P(z)$ vanishes.

Let denote

$$h(z) = \exp\left\{\int_1^z \frac{M(z)}{\sqrt{R(z)}}dz\right\},\quad h(z;c) = \exp\left\{\int_1^z\left[\frac{\sqrt{R(z)}+\sqrt{R(c)}}{z-c} + M_c(z)\right]\frac{dz}{2\sqrt{R(z)}}\right\},$$

where c - - finite point of ϱ and $M(z)$, $M_c(z)$ - - polynomials of ϱ -th

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degree with coefficients 1 for z^{ϱ}. The coefficients of $M(z)$, $M_c(z)$ are determined from the demand that the functions $h(z)$, $h(z;c)$ have on ϱ a unique modulus. For a positive continuous $\varphi(x)$ $(x \in E)$ let denote:

$$\mathfrak{G}[\varphi(x)] = \exp\left\{ \frac{1}{\pi} \int_E \frac{M(x)}{\sqrt{-R(x)}} \ln \varphi(x) dx \right\},$$

where $\sqrt{-R(x)}$ is positive in $(B_{\varrho}, 1)$. Then it holds the representation

$$p(z, \sqrt{R(z)}) = \frac{A}{[h(z)]^n} \prod_{j=1}^{\varrho} h(z;a_j) \left[\prod_{k=1}^{\varrho} h(z;\alpha_k)\right]^{-1} \prod_{k=1} h(z;\gamma_k) \prod_{i=\lambda+1}^{\varrho} h(z;\gamma_k^i)$$

where $A = 2\tau^n \mathfrak{G}\left[\sqrt{\frac{P(1)}{P(x)}}\right] \Gamma^*(\gamma_1, \gamma_2, \ldots, \gamma_{\varrho})$, $\tau = \lim\limits_{z \to \infty} \frac{z}{h(z)}$ is the (1)

transfinite diameter of E, and where a finite constant $L > 1$ exists such that $\frac{1}{L} < \Gamma^*(\gamma_1, \ldots, \gamma_{\varrho}) < L$. From (1) it follows that for every $x \in E$ and $n > p$:

$$\left| \sqrt{s(x)}\; T_n(x;P) \right| < C \sqrt{P(x)} \sqrt{N_n[P]}$$

where C only depends on E and $N_n[P] = 2\tau^{2n} \mathcal{G}\left[\frac{1}{P(x)}\right] \Gamma(\gamma_1, \gamma_2, \ldots, \gamma_s)$,
where $\frac{1}{L} < \Gamma < L$.

Theorem 1 : If the positive function $t(x)$ $(x \in E)$ is continuously differentiable and if the modulus of continuity $\omega_1(\delta)$ of its first derivative satisfies the condition

$$\lim_{n \to \infty} \omega_1\left(\frac{1}{n}\right) \ln n = 0$$

then for all sufficiently large n and every $x \in E$ it holds

$$\left| \sqrt{S(x)}\; T_n(x,t) \right| < C\tau^n \sqrt{t(x)}\; \mathcal{G}\left[1/\sqrt{t(x)}\right] , \qquad (4)$$

where C is a constant depending only on E.
Theorem 2 : Assume that the positive function $t(x)$ $(x \in E)$ possesses a continuous second derivative, the modulus of continuity of which satisfies

the condition $\lim\limits_{n\to\infty} \omega_2\left(\frac{1}{n}\right) \ln n = 0$. Let $P(x)$ be a positive polynomial on $[-1, +1]$ of even degree, where

$$\int_E \ln t(x) \frac{x^k\,dx}{\sqrt{-R(x)}} = \int_E \ln P(x) \frac{x^k\,dx}{\sqrt{-R(x)}} \qquad (k = 0,1,2,\ldots, \varrho - 1).$$

In this case for $n \to \infty$ it holds uniformly on E the asymptotic relation

$$\frac{T_n(x;\ t)}{\sqrt{t(x)}\sqrt{N_n^*[t]}} \sim$$

$$\sim \frac{1}{\sqrt{P(x)}\sqrt{N_n[P]}}\left\{T_n(x;P)\cos\psi(x) - \frac{\sqrt{-R(x)}}{S(x)}U_{n-1}(x;P)\sin\psi(x)\right\}$$

where

$$N_n^*[t] = N_n[P]\,\mathcal{G}\,[P(x)/t(x)]$$

and for $n \to \infty$

$$N_n^*[t] \sim N_n[t] = \frac{1}{\pi} \int_E [T_n(x;t)]^2 \frac{S(x)}{\sqrt{-R(x)}} \frac{dx}{t(x)},$$

while $\psi(x)$ is given by

$$\psi(x) = \frac{1}{2\pi} \text{ V.P. } \int_E \frac{\sqrt{-R(x)}}{\sqrt{-R(\xi)}} \frac{\ln\frac{t(\xi)}{P(\xi)}}{x-\xi} d\xi$$

A.F. Timan is mentioned in the paper. There are 2 Soviet-bloc references and 1 non-Soviet-bloc reference. The reference to English-language publication reads as follows: G. Szegö, Orthogonal polynomials, 1939.

ASSOCIATION: Kharkovskiy gosudarstvennyy universitet imeni A.M.Gor'kogo (Khar'kov State University imeni A.M. Gor'kiy)
PRESENTED: January 21, 1961, by S.N. Bernshteyn, Academician
SUBMITTED: January 19, 1961

TOMCHUK, Yu.Ya.

Polynomials orthogonal on a given system of arcs within a unit circle. Dokl. AN SSSR 151 no.1:55-58 Jl '63. (MIRA 16:9)

1. Khar'kovskiy gosudarstvennyy universitet im. A.M.Gor'kogo. Predstavleno akademikom S.N.Bernshteynom.

(Polynomials)

TOMCHUK, Yu.Ye.

Orthogonal polynomials on a system of intervals on the real axis. Uch. zap. KhGU 135:93-128 '64. (MIRA 17:10)

TOMCIK, J.

Perspective Development of nuclear techniques for peaceful use; p. 527
TECHNICKA PRACA. Czechoslovakia, Vol. 11, No. 7, July 1959.

Monthly List of East European Accessions (EEAI), LC. Vol. 8, No. 9, Sep 1959
Uncl.

TOMCIK, J.

"Nuclear energy, its production and use". Reviewed by J. Tomcik.
Jaderna energie 6 no.7:252 Jl '60.

23037

21, 1920

SLOV/001/60/000/007/001/004
D219/D305

AUTHOR: Tomčik, Ján, Engineer, Director

TITLE: The first Czechoslovak nuclear power plant in Bohunice

PERIODICAL: Technická práca, no. 7, 1960, 555 - 558

TEXT: The article describes the design of the first Czechoslovak nuclear power plant which will be constructed with Soviet assistance in Bohunice. The heterogeneous, heavy-water moderated, gas-cooled reactor will have a thermal output of 590 Mw and an electrical output of 150 Mw. The heat is conveyed by CO_2 with a pressure of 66 kg/cm^2, entering the reactor with a temperature of 105°C and leaving the reactor with a temperature of 425°C. The basic thermal parameter of the entire power plant is the surface temperature of the fuel elements which, for the Mg-Be cladding used, must not exceed 500°C. The active section of the reactor is 400 cm high and 416 cm in diameter. The fuel assemblies are inserted into the technological channels, additional 40 channels serve the regulation and control. One reactor load consists of

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cooled with ventilated cooling towers. The total thermal efficiency of the cycle is 25.5%. The control and safeguarding system of the reactor automatically controls the output and stops the reactor operation in case of emergency. The control of the power plant itself will probably also be fully automated. One of the principle problems is to secure reactor cooling (forced CO_2 circulation) in the case of turbogenerator break-down. The blowers for circulation of primary coolant will then be driven from the 220 kv system by reversed power flow. Even if the stability of the 220 and 110 kv grid fails, the blower drive will be switched to one of the running-out turbogenerators which secures cooling for approximately 30 seconds. During this time, it is expected that a generator of a nearby hydroelectric power plant can be switched-in as a standby source. The first Czechoslovak nuclear power plant was designed for natural uranium and D_2O moderation for economical reasons. The high pressure for the primary coolant was chosen to save heavy water. With its technological characteristics, the Czechoslovak reactor ranges between a graphite-

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25 tons of natural uranium (assumed specific output 23.2 kw/kg), the expected fuel burn-up is 3,000 Mwd/t. The moderator charge consists of 48 tons of externally cooled heavy water which has a maximum temperature of 90°C. The fuel assembly is 4 m long and consists of a Mg-alloy tube in which the uranium rods are arranged in concentric circles. Each uranium rod is 4 mm in diameter, clad with a 0.45 mm thick Mg-Be layer. The primary coolant circuit with forced CO_2 circulation (6 blowers) includes 12 branch lines, coming from the chambers for hot and cold gas, and leading to the steam generators. The thermal energy is transferred from the primary to the secondary coolant circuit by heat exchangers consisting of a large tube (133 mm in diameter) surrounding 19 small tubes with the working fluid (steam and water). The primary circuit has a pressure drop of 12 atm, a temperature span of 95 - 425°C, and the temperature difference between the CO_2 and the steam in the generators is 15 - 20°C. the steam generators produce medium-pressure (400°C, 29 atm) and low-pressure (180°C, 2 atm) steam, driving three 50 Mw turbogenerators. The turbine condensers, which operate with an underpressure of 0.054 atm, are circulation

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moderated, gas-cooled and a water-moderated and-cooled reactor; the reactor vessel resembles that of a pressurized-water cooled and moderated reactor. Due to the short life of the natural-uranium elements (1/3 year), the fuel assemblies will be exchanged during operation. However, this complicates the entire installation, and it is estimated that 60% of the total capital expenditures will be used for the primary coolant circuit(including the steam generators, pipings, D_2O, etc.). There is 1 table.

ASSOCIATION: Jadrová elektráreň, Bohunice (Nuclear Power Plant, Bohunice).

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TOMCIK, JAN.

L 18836-65 EWT(d)/EWT(m)/EPF(n)-2/EWP(c)/EWP(k)/EWP(h)/EPA(bb)-2/T/EWP(1)
Pf-4/Pu-4 AEDC(b)/SSD
ACCESSION NR: AP4044865 Z/0038/64/000/009/0312/0322

B

AUTHOR: Hulovec, Jan (Gulovets, Ya.); Juza, Jan (Yuza, Ya.); Komarek, Arnost; Korenek, Jan (Kerzhenek, Ya.); Wagner, Karel (Vagner, K.); Krizek, Vladimir (Krzhizhok, V.); Tomcik, Jan (Tomchik, Ya.)

TITLE: Development and construction problems of the first Czechoslovak nuclear reactor power plant 19 10- 14

SOURCE: Jaderna energie, no. 9, 1964, 312-322

TOPIC TAGS: nuclear power plant, reactor, pressure vessel, power output, fuel element

ABSTRACT: This article reports on the principal scientific research which was necessary in connection with the testing of the reliability of all the important units of the first Czechoslovak nuclear electric power plant of 150-Mw power output, and the present stage of the development and production of the technological installations and of the construction of the power plant. The plant uses gas cooling and a heavy-water reactor with natural metallic uranium and is being built at the present time in the CSR. The relatively large output design of the Czechoslo-

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-vak plant has delayed construction as it has been necessary to design, construct, and test many parts of the technological installation with a view to much greater perfection than would have been the case were the plant of low-power output. More time will be required than originally planned to put the functional units and the whole plant into operation, since the unit of greater power was designed with a view to greater economy of operation, and has by far a more complicated construction than units whose main purpose is the testing and proving of design types in operation. Great attention has been given to the design and development of the fuel-element changing mechanisms; its individual units as well as the whole prototype mechanism have been functionally tested. The mechanisms of all the control rods and safety rods have been subjected to all-round, exhaustive testing on a special stand with models of the mechanisms of a 1:1 scale at full operating temperature and CO_2 coolant pressure. Many tests were made on models of the reactor shielding. Inasmuch as the technological installations of the plant are in a developmental stage, the discussion is limited to future prospects from the point of view of technical performance figures, of which the most important is the maximum unit power that can be generated. Given the fuel element concept described

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here, it is not necessary to reckon with either a sharply increased active zone height or with increased thermal power drawn from the unit volume of active zone, which is already fairly high in the first electric power plant (10 Mw/m^3). It may be expected, therefore, that the 200-Mw power stage will have a pressure chamber of 6.4 m average diameter, and the 400-Mw stage a pressure chamber of 8.8 m diameter. The height of the pressure chamber would not at the same time be substantially changed. The pressure chamber of the reactor of the first electric power plant cannot be transported fully assembled. It was designed, therefore, so that it could be assembled at the plant construction site. The engineering and operation reliability of the steam generator were tested on a full-scale model of one section. Adjustable blade flow control in exhaust and sealing (packing) systems was tested on a 1:1 scale blower model. The effect of thermal shock on the piping in the case of emergency reactor shutdown, and the possibility of using turbine units from classical electric power plants under the operating conditions prevailing in the nuclear plant in view of the high moisture content of the vapor, was investigated. Another nuclear electric power plant with a reactor of a 200-Mw unit power output is being designed and planned on the basis of the design and development experience discussed here. Increased unit power output of this type of

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reactor will obviously depend on changes in the concept of the core of the reactor itself, in particular of the fuel element. This problem is now under study. Orig. art. has: 19 figures.

ASSOCIATION: [Hulovec, Juza, Komarek, Korenek, Wagner] Zavody V. I. Lenina, Pilsen (Lenin Plant); [Krizek] Prvni brnenska strojirna, Zavody Klementa Gottwalda (First Brno Machine Building Plant, Klement Gottwald Plant); [Tomcik] Jaderna elektraren (Nuclear Electric Power Generating Plant)

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Card 4/4

MICHALICKOVA, Jaroslava, Doc. MUDr.; TOMCIKOVA-MIKLETICOVA, Otilia, MUDr.

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"Anaplasmosis in Cattle in the Peoples' Republic of Macedonia."

Belgrade, Veterinarski Glasnik, Vol 17, No 4, 1963; pp 323-328.

Abstract [English summary modified]: Macedonia is only Yugoslav state in which bovine anaplasmosis is a problem - presumed imported with stock from abroad; now thought to be spread by ticks and other arthropods. Various antiseptics and antibiotics are used with mediocre effect; also insecticides. Nine Yugoslav, 5 Western and 5 Soviet references.

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(PARA-AMINOSALICYLIC ACID, metab.
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(MYCOBACTERIUM, metab.
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